Directional Shift of Trade Winds at Honolulu

CHESTER K. WENTWORTH[1]

FOR MANY YEARS it has been known to those persons especially interested in weather conditions that a gradual shift of the direction of prevailing surface wind at Honolulu has been in progress. The data on which such a conclusion can be reached are now sufficient to give a more complete picture of the shift, though they have not been made available in a uniform published form. The present paper has made use of data, partly published and partly unpublished, furnished by the Weather Bureau office at Honolulu. From 1905 to 1922 the weather vane was on the Young Hotel Building, 121 feet above the ground and 26 feet above the roof. Since 1922 the weather vane has been on the Federal Building, 99 feet above the ground and 17 feet above the roof. The former location is about 700 feet northwesterly from the latter and about 300 feet nearer the crest of the Koolau Range. The records show no indication of change due to the difference in location.

The Hawaiian Islands are in a latitude zone dominated by northeasterly trade winds, as shown by the fact that over the past 40 years of record the winds in the northeast and east sectors at Honolulu have averaged about 81 per cent of the total time in hours. Similar conditions are shown at various other stations but it is only at the Honolulu station that the record is of sufficient length and that the data are tabulated in a form which permits detailed presentation.

The shift of the prevailing wind direction was first noted in published form by E. A. Beals in 1927 (The northeast trade winds of the North Pacific. *U. S. Monthly Weather Rev.* 55: 211–221). He showed that a shift from northeast toward east was then in progress. He discussed the possible influence of changes in value and position of high pressure areas north and east of Honolulu, as well as changes in ocean temperature. He concluded that the "true explanation is not at once apparent."

In 1938, in an unpublished manuscript (Wentworth, C. K. *Geology and ground water resources of the Palolo-Waialae district (Honolulu)*. Board of Water Supply, Manuscript Report, 274 pages; p. 29), the writer extended the tabulation by 5-year intervals and showed that the swing from northeast toward east continued until 1930 and appeared to slow down from 1930 to 1934. Since there is no possibility of such a shift being continuous in one direction, it then appeared that a reversal might be imminent. Only recently, in the course of further discussion of climatic data, the percentages of hours of wind in the northeast and east sectors for the years 1935 to 1946 were secured through the courtesy of the Weather Bureau office at Honolulu and the analysis was extended to include the whole period from 1905 to 1946. It is now clearly shown that the anticipated reversal has taken place. The 5-year moving average used as an index had, by 1944, returned from the extreme easterly position more than halfway to the apparent extreme northeasterly position suggested by the data for the period 1907 to 1910 (Fig. 1).

In order that the reader may evaluate the general picture presented here, some explanation of the method of analysis is warranted. The fundamental data consist of a summarized record of wind in each of the eight sectors centered at the four positions of north, west, south, and east, and the four intermediate (45°) posi-

[1] Geologist, Honolulu Board of Water Supply. Manuscript received May 23, 1948.

tions, of which northeast is one. The total of wind in each sector for each month is tabulated both by miles and by hours, and is summarized in the same way for each calendar year.

This study is based on the number of hours shown in the two sectors east and northeast, since these two sectors, or one fourth of the whole wind rose, have accounted, over the 40-year period, for an average of about 81 per cent of the total time. It is evident that there is a strong central tendency in these two sectors, and the shift of trade-wind direction in degrees has been deduced by comparing the changing proportions carried in the two sectors. For example, in the period of 2 or 3 years around 1908, the percentage of northeast wind by hours was about 56, while that of east wind was only about 24. On the other hand, by about 1935 and for 3 or 4 years before and after, the percentage of northeast wind was only about 22, and that of east wind had increased to 57. The annual percentages are shown graphically in Figure 2.

The annual data are somewhat ragged, suggesting that a number of minor factors are involved, but the general shift is nevertheless clearly shown. In order to smooth out the lesser variations and combine the concentration of wind in the two sectors, the algebraic difference in percentages (east–northeast) for each year has been tabulated and then a 5-year moving average computed. This average has been plotted in Figure 1 with the point of the arrow placed at the middle year of the 5-year period.

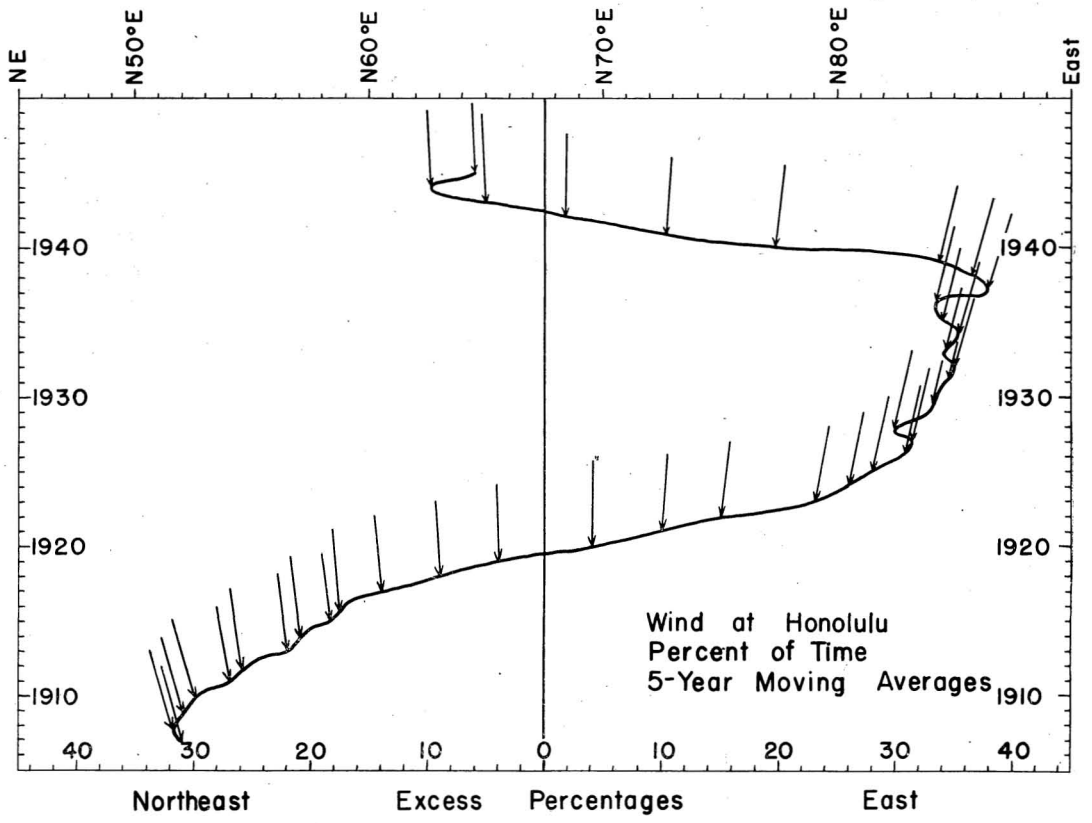

FIG. 1. Diagram showing changing wind directions at Honolulu from 1907 to 1945. Each arrow represents the mean position for 5 years, recorded at the middle year, in terms of the excess of east wind over northeast wind, positive to right, negative to left. The attitudes of the arrows give approximate azimuths, the vertical being N 67.5 E.

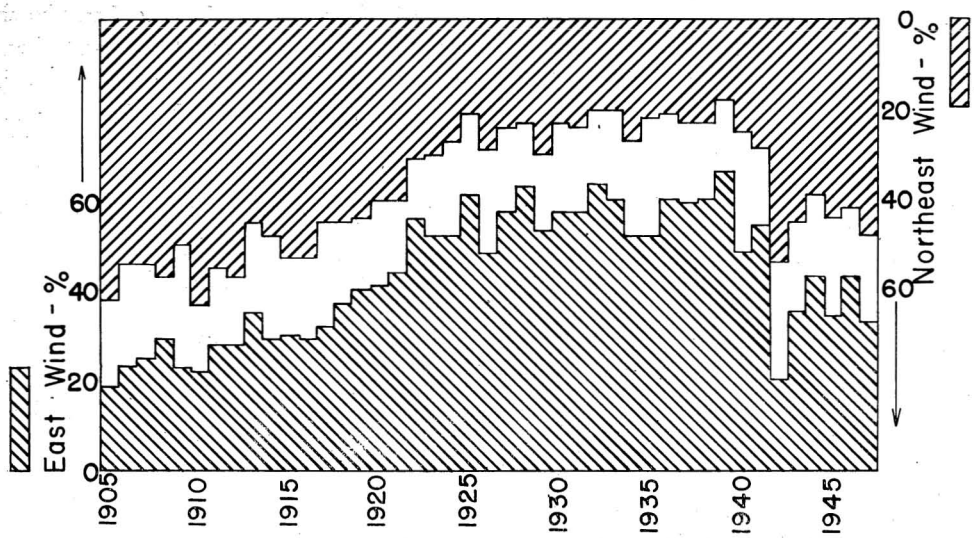

FIG. 2. Graph showing changing proportions of east wind (bottom) and northeast wind (top), by the year, from 1905 to 1947. The residue (blank) of less than 20 per cent includes all other wind directions.

This plotting gives a clear indication of swing but some angular scale is desirable. This has been developed by regarding the proportions of wind in the two major sectors (northeast and east) and in the two adjacent ones (north and southeast) as representing approximately a normal curve of frequency distribution. By very approximate account of the changes in the lesser proportions with the change in the major, it has been developed that 10 units of change in the difference between northeast and east percentages is roughly equivalent to 5 degrees change in direction of the prevailing wind or the central position. For the present purpose, and to give some sense of direction to the graph and the arrows as drawn, this relationship is sufficient, though rigorous calculations or actual measurements through a period of some years would possibly indicate a moderate error in this ratio of comparison and also might show that the ratio is not quite uniform throughout.

The data represented in Figure 1 leave little doubt that a systematic shift is in progress and that it is cyclical in character. At the eastern extreme, the successive positions of arrows also suggest the swinging of a lesser cycle on the major one, a rather common state of affairs. Since the major cycle is not complete, any estimate that might be made as to period must be very rough. Perhaps we can go no further than to note that the three quarter-periods between the approximate points 1908–1920–1934–1942 are 12, 14, and 8 years, suggesting a whole period of the order of 45 years. No basis is known for such a period and the writer desires only to state roughly the condition that is indicated by the data in Figure 1.

The purpose of this note is to show that there is a definite, rather smooth, cyclical swing which will apparently complete one whole period from 1908 within the 1950 to 1960 decade. To determine its cause will require more knowledge of other cycles than the writer, or perhaps anyone else, now possesses. To determine its true period will of course require a much longer period of record, and the nature of the various wind patterns that enter to produce the frequency distribution could be better analyzed if a more detailed record could be obtained over a number of years.